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First observation on the antennal cleaning behaviour in Archaeognatha (Insecta)

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Abstract

Antennal cleaning behaviour in Archaeognatha is documented for the first time, supported by photographs and video observations of a male *Petrobiellus akkesiensis* (Machilidae, Petrobiellinae) collected from Hokkaido, Japan. These observations indicate that the long-standing notion that antennal cleaning behaviour is absent in Archaeognatha may apply only to Machilinae. During antennal cleaning, the foreleg was positioned near the mouthparts with its tip directed mesally, suggesting that the foreleg assists the mouthparts to hold the antenna during the cleaning process.

Key Words

Antenna, grooming, jumping bristletails, Machilidae, Petrobiellinae, *Petrobiellus*

Introduction

Archaeognatha, commonly known as jumping bristletails, are an order of apterygote ectognathans comprising approximately 600 described species, distributed across all continents, except Antarctica (Sturm and Machida 2001; Mendes 2018; Palacios-Martinez et al. 2025). The classification of extant species in this order, as proposed by Sturm and Machida (2001), recognises a single superfamily, Machiloidea, including two families, namely, Machilidae, in which three subfamilies, i.e. Machilinae, Petrobiinae and Petrobiellinae, are distinguished and Meinertellidae, along with three genera not assigned to a family, i.e. *Mesomachilis*, *Charimachilis* and *Ditrigoniophthalmus*: *Turquimachilis* is considered closely related to *Charimachilis* (Sturm and Bach de Roca 1993; Sturm and Machida 2001; Bach de Roca et al. 2013; Zhang et al. 2018).

The subfamily Petrobiellinae includes only one genus *Petrobiellus* established by Silvestri (1943) and the absence of scales on the entire antenna, maxillary and labial palpi, thoracic appendages and styli is one of the notable features of *Petrobiellus* (Kaplin 1985; Sturm and Machida 2001; Mtow and Machida 2024, 2025).

Antennal cleaning behaviour plays an essential role in maintaining olfactory function in arthropods (Jander 1966) and particularly, in insects (Böröczky et al. 2013) and it can be a potential source of phylogenetic information that helps to elucidate the evolution of the groups (Basibuyuk and Quicke 1999). This behaviour has been widely documented across numerous taxa, including apterygote hexapods (excluding Protura, which lack antennae), such as Collembola (e.g. Simon 1961; Waldorf 1978), Diplura (Valentine and Glorioso 1978) and Zygentoma (Jander 1966). However, antennal cleaning behaviour has not been observed in Archaeognatha to date, despite the frequent and continuous use of the antenna during locomotion, feeding and mating (Sturm 1955; Sturm and Bach de Roca 1993; Sturm and Machida 2001).

In the present note, I briefly report and illustrate the first recorded instance of antennal cleaning behaviour in Archaeognatha, using a species of *Petrobiellus* as a representative example.

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Materials and methods

On 19 October 2021, 65 archaeognathan specimens (25 males and 40 females) identified as *Petrobiellus akkesiensis* were collected from a rocky shore near Cape Washibetsu, Noboribetsu City, Hokkaido, Japan (approximately 42°21'12.279"N, 141°03'14.705"E). These specimens were maintained in the laboratory following the rearing protocol described by Mtow and Machida (2025). Photographs and video recordings were obtained using a Ricoh GXR digital camera.

Results and discussion

At approximately 23:45 h on 26 October 2021, antennal cleaning behaviour was observed for several minutes in a captive male *Petrobiellus akkesiensis* after the individual was transferred to a plastic tray (373 mm × 273 mm × 63 mm) lined with black paper (Fig. 1A–D; Suppl. material 1). Initially, the basal region of the right antennal flagellum was bent, with its distal end directed posteriorly (Fig. 1B) and cleaning of the flagellum began; during this process, the scapus and pedicellus remained orientated anteriorly and no cleaning of these segments was detected. In a dorsal view, abduction–adduction movements of the maxillary palpi, along with slight movements of the labial palpi and right foreleg, were observed, whereas no movement of the mandible could be observed from this angle. Cleaning progressed from the base towards the distal tip of the flagellum and the middle region of the flagellum became markedly bent during cleaning of the distal portion (Fig. 1C). Throughout the entire cleaning sequence, the right foreleg was positioned near the mouthparts with its tip orientated mesally (Fig. 1B–D).

Similar antennal cleaning behaviour was subsequently observed on the left antenna in the same individual and a video documenting the behaviour is provided (Suppl.

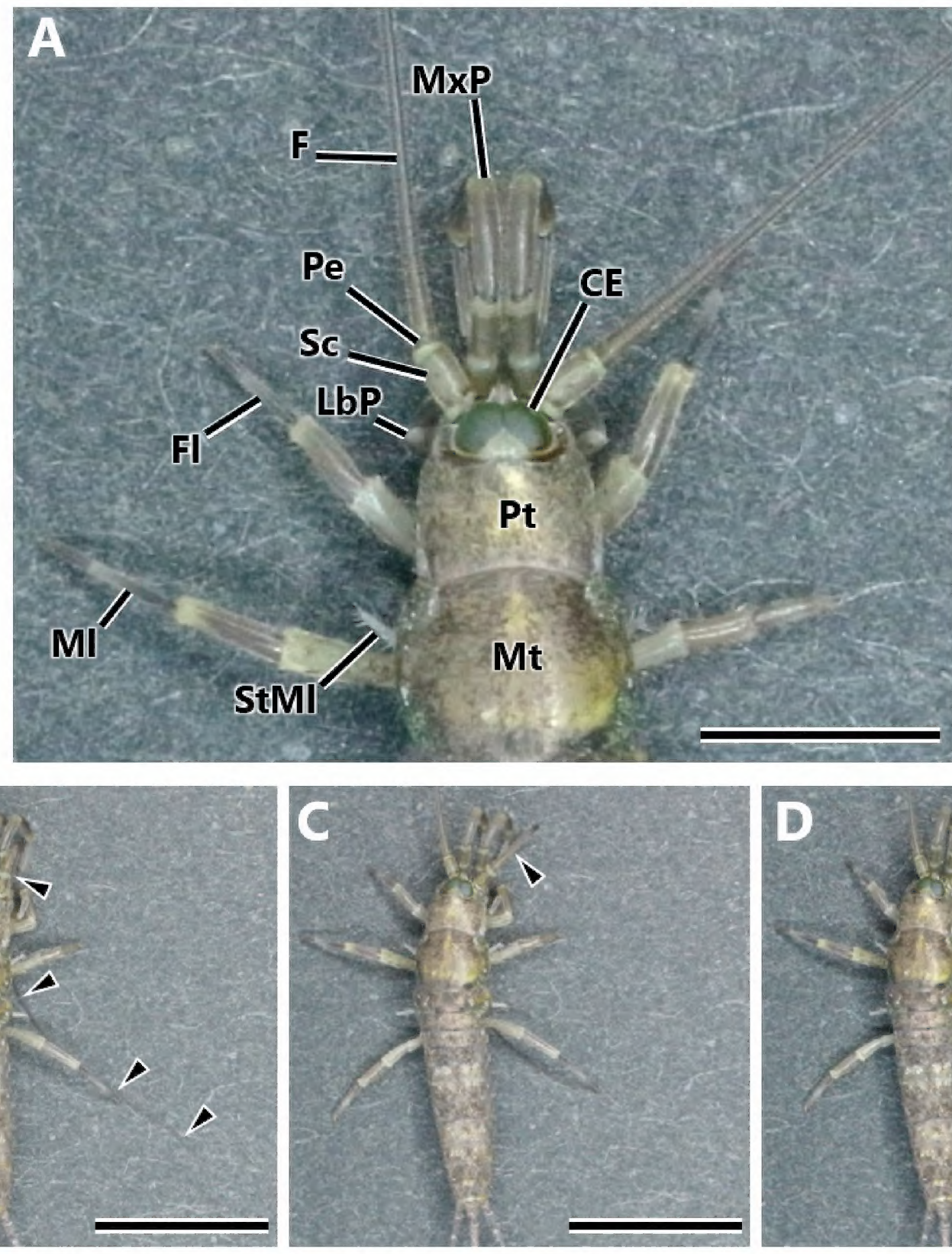

Figure 1. *Petrobiellus akkesiensis*, male, dorsal view. **A.** Enlargement of the anterior part of body; **B–D.** Antennal cleaning behaviour observed indoors on 26 October 2021. Arrowheads indicate the flagellum. Abbreviations: CE, compound eye; F, flagellum; Fl, foreleg, LbP, labial palp; Ml, mid-leg; Mt, mesothorax; MxP, maxillary palp; Pe, pedicelus; Pt, prothorax; Sc, scapus; StMl, stylus of mid-leg. Scale bars: 2 mm (**A**); 5 mm (**B–D**).

material 1). In this video, the left mid-leg was positioned close to the left foreleg, although no movement of the mid-leg was detected during cleaning. Despite continued rearing of this and other individuals until at least 10 May 2022, antennal cleaning behaviour was not observed in any additional individuals.

The observations of *P. akkesiensis* presented here represent the first documented evidence of antennal cleaning behaviour in Archaeognatha. Sturm and Machida (2001) suggested that antennal cleaning behaviour is absent in Archaeognatha because such behaviour would damage the scales covering the antenna, based on their assumption that a fully scaled antenna, as observed in Machilinae, represents the groundplan condition within Machiloidea. Although the presence/absence of the antennal scale and the antennal cleaning behaviour in Archaeognatha requires further investigation, the present findings suggest that the interpretation by Sturm and Machida (2001) may be applicable only to Machilinae and raise the possibility that antennal cleaning behaviour may occur also in other archaeognathans, such as *Ditrigoniophthalmus* and Meinertellidae, in which the antennae are devoid of scales as Petrobiellinae, as well as Petrobiinae, in which the flagellum lacks scales (e.g. Kaplin 1979, 2000; Sturm and Machida 2001). Nevertheless, antennal cleaning behaviour in Archaeognatha is likely rare in nature, given that it was observed only once in a single *Petrobiellus* individual under captive conditions.

In *P. akkesiensis*, each foreleg was positioned near the mouthparts with its tip directed mesally during the cleaning process, suggesting that the foreleg assists the mouthparts to hold the antenna. The involvement of forelegs in antennal cleaning varies amongst apterygote insects: in Zygentoma, forelegs use during cleaning has been documented only in *Lepisma saccharinum* Linnaeus, 1758, but not in *Thermobia domestica* (Packard, 1873) (Jander 1966); in Diplura, forelegs are rarely used in *Campodea plusiochaeta* Silvestri, 1912 of Rhabdura, but occasional foreleg use has been reported in *Metajapyx subterraneus* (Packard, 1874) and *M. steevesi* Smith & Bolton, 1964 of Dicellurata (Valentine and Glorioso 1978). To further understand cleaning-related structures of *P. akkesiensis* and other apterygote insects, such as the mouthparts and forelegs, a more detailed analysis is required and an inverted stereomicroscope system described by Mtow and Machida (2025) could be useful in this regard.

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References

Bach de Roca C, Fanciulli PP, Cicconardi F, Molero-Baltanás R, Gaju-Ricart M (2013) Description of a new genus and a new species of Machilidae (Insecta: Microcoryphia) from Turkey. Soil Organisms 85(1): 31–39. https://www.senckenberg.de/wp-content/uploads/2019/08/04_artikel_carmen_bach_de_roca_et_al-.pdf

Basibuyuk HH, Quicke DLJ (1999) Grooming behaviours in the Hymenoptera (Insecta): Potential phylogenetic significance. Zoological Journal of the Linnean Society 125(3): 349–382. https://doi.org/10.1111/j.1096-3642.1999.tb00597.x

Böröczky K, Wada-Katsumata A, Batchelor D, Zhukovskaya M, Schal C (2013) Insects groom their antennae to enhance olfactory acuity. Proceedings of the National Academy of Sciences of the United States of America 110(9): 3615–3620. https://doi.org/10.1073/pnas.1212466110

Jander U (1966) Untersuchungen zur Stammesgeschichte von Putzbewegungen von Tracheaten. Zeitschrift für Tierpsychologie 23(7): 799–844. https://doi.org/10.1111/j.1439-0310.1966.tb01711.x

Kaplin VG (1979) A new genus and new species of bristletails (Thysanura, Machilidae) from Kamchatka and Primorsky Krai. In: Medvedev GS (Ed.) New Species of Insects in the Asian Part of the USSR. Transaction of the Zoological Institute of the Academy of Sciences of the USSR, Leningrad, 88: 3–9. [in Russian]

Kaplin VG (1985) On the classification and phylogeny of the Machilidae (Thysanura, Microcoryphia). Entomological Review 64(3): 117–131.

Kaplin VG (2000) The fauna of bristletails of the family Machilidae (Thysanura) from Altai. Zoologicheskiy zhurnal [Зоологический журнал] 79(9): 1053–1060. [in Russian with English abstract]

Mendes LF (2018) Biodiversity of the Thysanurans (Microcoryphia and Zygentoma). In: Foottit RG, Adler PH (Eds) Insect Biodiversity: Science and Society, II. John Wiley and Sons Ltd, New York, 155–198.

Mtow S, Machida R (2024) What are *Halomachilis akkesiensis* and *Halomachilis kojimai* described from Hokkaido, Japan? (Insecta: Archaeognatha: Machilidae). Zootaxa 5543(3): 445–450. https://doi.org/10.11646/zootaxa.5543.3.10

Mtow S, Machida R (2025) Mating behavior of the jumping bristletail *Petrobiellus akkesiensis* (Archaeognatha: Machilidae: Petrobiellinae): Direct spermatophore transfer via genital coupling. Arthropod Systematics & Phylogeny 83: 737–756. https://doi.org/10.3897/asp.83.e159694

Palacios-Martinez I, Jiménez-Ruiz Y, Otero-Ferre P, García-París M (2025) Systematics of the genus *Dilta* Strand, 1911 (Machilidae) in the Canary Islands (NW Africa, Spain) with comments on the phylogeny of Microcoryphia (Insecta). Zoologischer Anzeiger 317: 1–18. https://doi.org/10.1016/j.jcz.2025.05.005

Silvestri F (1943) Contributo alla conoscenza dei Machilidae (Insecta, Thysanura) del Giappone. Bollettino del Laboratorio di Zoologia, generale e agraria della R. Scuola superiore d'Agricoltura in Portici 32: 283–306.

Simon HR (1961) Beobachtungen zum Verhalten arthropleoner Collembolen (Apterygota). Deutsche Entomologische Zeitschrift 8: 215–221.

Sturm H (1955) Beiträge zur Ethologie einiger mitteldeutscher Machiliden. Zeitschrift für Tierpsychologie 12(3): 337–363. https://doi.org/10.1111/j.1439-0310.1955.tb01532.x

Sturm H, Bach de Roca C (1993) On the systematics of the Archaeognatha (Insecta). Entomologia Generalis 18(1–2): 55–90. https://doi.org/10.1127/entom.gen/18/1993/55

Sturm H, Machida R (2001) Archaeognatha. In: Kristensen NP, Beutel RG (Eds) Handbook of Zoology. Volume 4. Arthropoda: Insecta. Part 37. Walter de Gruyter, Berlin, New York, 1–213.

Valentine VD, Glorioso MJ (1978) Grooming behavior in Diplura (Insecta: Apterygota). Psyche (Cambridge, Massachusetts) 85(2–3): 191–200. https://doi.org/10.1155/1978/46347

Waldorf ES (1978) Variation in self-grooming in male *Sinella coeca* (Collembola: Entomobryidae). Transactions of the American Microscopical Society 97(1): 111–116. https://doi.org/10.2307/3225690

Zhang W, Li H, Shih C, Zhang A, Ren D (2018) Phylogenetic analyses with four new Cretaceous bristletails reveal inter-relationships of Archaeognatha and Gondwana origin of Meinertellidae. Cladistics: The International Journal of the Willi Hennig Society 34(4): 384–406. https://doi.org/10.1111/cla.12212

Supplementary material 1

Antennal cleaning behaviour of a male *Petrobiellus akkesiensis*, observed indoors

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